INVESTIGATION OF A HIGH REPETITION RATE TEA-CO_2 LASER

By

SIEW WEE ONG

B. Sc. (Hons.)

Department of Physics

Faculty of Science

Dissertation Presented for the

Degree of Master of Science

University of Malaya

Kuala Lumpur

(1996)

ACKNOWLEDGMENTS

I thank my immediate supervisor, Professor K. S. Low for giving me the opportunity to engage in this research project, and for his help and concern. My sincere thanks goes to Associate Professor T. Y. Tou, my co-supervisor, for sharing his vast knowledge and support, and invaluable discussions and guidance during the preparation of this thesis.

Special thanks goes to Mr. K. K. Tham for his help and discussions in the experimental work and preparation of this thesis. I would also wish to thank Mr. W. T. Loo for his advice and assistance in the design and construction of the laser system. To my research colleagues, Dr. Simon Wong, Mr. W. S. Seow, Mr. K. F. Lee, Mr. D. S. Ong, Mr. M. D. Tan, Mr. B. C. Quek, and Miss Y. P. Yap, I extend my thanks for their assistance in many ways occasionally. Special thanks also goes to my friends who care about me, especially Miss Betsy Lee and Miss Sabrina Ng.

I also thank the Laser and Optoelectronics Laboratory, Institute of Advanced Studies, University of Malaya for providing me the research facilities and the financial support.

Finally, I am grateful for the love, encouragement, and support from my family and this work is dedicated to them.

W. O. Siew

Nov. 1996

ABSTRACT

A high-repetition-rate (HRR) transversely excited atmospheric (TEA) CO_2 laser was designed and operated up to 300 Hz, which produced an average output power of 70 W in CO_2:N_2:He-8:8:84. This laser was driven by an air-blown two-stage spark gap and the high voltage charging unit was operated using a command charging mode controlled air-blown spark gap. A linear sliding-spark array was used as the ultraviolet preionization source for obtaining uniform laser discharge between a pair of profiled Ernst electrodes.

The laser was first investigated for the single-pulse operation and its performance was characterized with respect to the preionizer-to-main time delay, the storage capacitor voltage, and the storage capacitance. The time-delay was obtained by the controlling breakdown of the second gap in the two-stage spark gap. A minimum time-delay was usually needed for achieving stable laser output energy, which depended on the storage capacitor voltage and circuit parameters.

In the HRR operation, the laser average output power increased linearly with the operating frequency until arc discharge limit. For a given arc-free frequency, the laser average output power was independent of the gas flow velocity. The maximum frequency for arc-free discharge decreased for slower gas flow velocities, from which a clearing ratio of about 4 was obtained. This maximum frequency was, however, independent of the input energy density if it is less than 60 J//-atm.

ABSTRAK

Satu laser karbon dioksida kadar ulangan tinggi ujaan melintang tekanan atmosfera telah direkabentuk dan dioperasikan sehingga 300 Hz, di mana ianya menhasilkan 70 W purata kuasa keluaran dalam CO_2:N_2:He:8:8:84. Laser ini telah didorongkan dengan satu pencucuh celah (spark gap) berdua tingkat tiupan udara dan unit pencasan bervoltan tinggi dioperasikan dengan mod terkawal pencasan berintah (command charging) pencucuh celah tiupan udara. Satu susunterbit pencucuh meluncur linear telah digunakan sebagai punca pra pengionan cahaya ultra lembayung untuk mendapatkan discas laser yang seragam di antara sepasang elektrod terprofil Ernst.

Laser itu diselidikkan dahulu dengan operasi denyutan tunggal and perlaksanaannya dicirikan berhubung dengan masa tunda pengion ke discas utama, voltan kapasitor storan, dan keapsitans storan. Masa tunda itu didapatkan dengan pengawalan pecah tebat oleh celah kedua bagi pencucuh celah berdua tingkat itu. Satu masa tunda minimum adalah diperlukan untuk mencapaikan tenaga keluaran laser yang stabil, di mana ianya bergantung kepada voltan kapasitor storan dan parameter-parameter litar.

Dalam operasi kadar ulangan tinggi, purata kuasa keluaran laser itu bertambah secara linear dengan frekuensi operasi sehingga had discas arka (arc discharge). Bagi frekuensi tanpa arka yang tertentu, purata kuasa keluaran laser itu tidak bergantung kepada kelajuan aliran gas. Frekuensi maksimum bagi discas tanpa arka berkurang dengan kelajuan aliran gas yang lebih perlahan, di mana nisbah bersihan yang lebih kurang 4 telah didapati. Walaupun demikian, frekuensi maksimum ini adalah tidak bergantung kepada kepadatan tenega masukan jika ianya adalah kurang daripada 60 J/l-atm.

CONTENTS